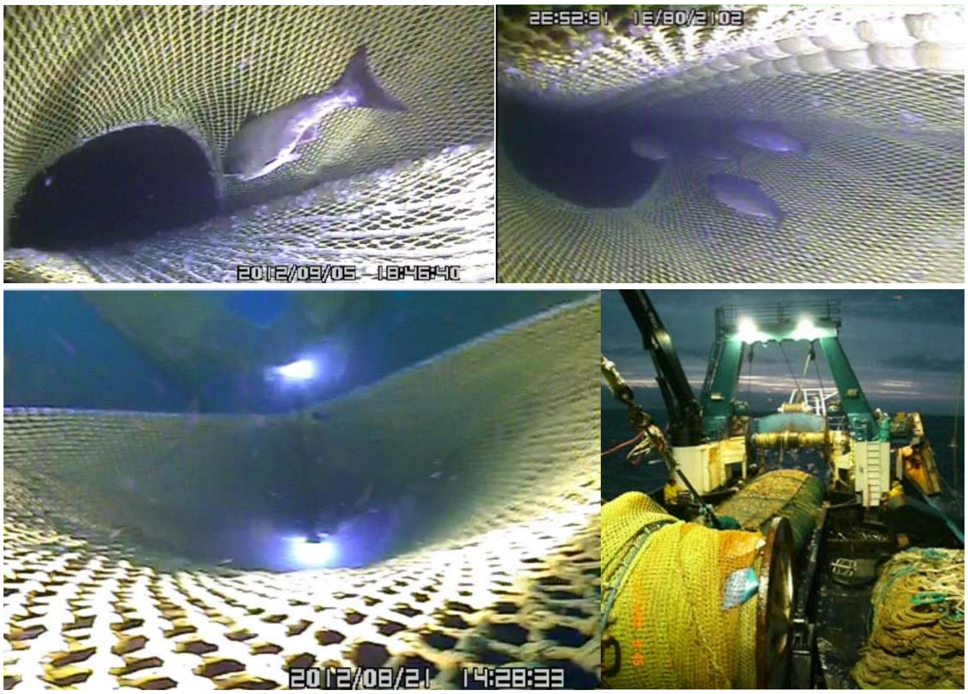
Salmon Excluder EFP 11-01 Final Report

June 2013



John Gauvin, North Pacific Fisheries Research Foundation, John Gruver, United Catcher Boat Association, Katy McGauley, Alaska Groundfish Databank, and Craig Rose, Alaska Fishery Science Center

Executive Summary

Salmon excluder designs have evolved considerably since experimental trials in the Bering Sea pollock fishery started in the fall of 2003. Design changes have been influenced by a suite of exempted fishing permit (EFP) tests and by feedback from fishermen using the various designs over the years since the EFPs started. This report details the latest performance testing under EFP 11-01 approved in 2010 with the objective of improving Chinook salmon escapement rates and finding a more effective excluder for chum salmon.

Specific objectives for EFP 11-01 were to: 1) Test in fall of 2011 whether the winter 2010 version of the flapper excluder would be more effective for chum salmon escapement than previous excluders which have generally been ineffective for chum escapement; 2) Test in winter 2012 whether the addition of artificial light to the area around the escapement portal of the flapper excluder would improve Chinook escapement rates; 3) Explore in fall 2012 whether modifications to the current design, including escapement portals at both the bottom and top of the net, would improve chum and/or Chinook escapement rates.

With regard to the first objective, the result was from the fall of 2011 was an 11% chum escapement rate with the flapper-style excluder device that worked well for Chinook escapement in 2010 without any modification. A second phase of testing with a small modification to that device flapper intended to facilitate chum escapement out the top of the net resulted in a 7% escapement rate. Both versions of the device had a very low rate of pollock escapement. Overall these results indicate some improvement in chum escapement over earlier trials but still considerably lower rates than what had been achieved with Chinook salmon. A big take home from this was that increasingly it appears that chum escapement out the top of the net with flapper-style excluders is not going to be workable.

One unanticipated result from the fall 2011 fieldwork was that the testing location for the Phase One testing afforded a unique opportunity to evaluate the winter 2010 flapper excluder for chum and Chinook escapement simultaneously. The Chinook escapement rate for the Phase One test was 38% with the 95% confidence intervals ranging from 24% to 50% at the same time that the relatively low (11%) chum escapement rate occurred.

For the evaluation of whether the addition of artificial light increased Chinook escapement in winter of 2012, the overall finding was that escapement rates were not improved with the added light and were in fact actually lower (nominally anyway). Another finding was that using light to augment escapement is trickier than anticipated. Light may well serve as attractant and, depending on how it is rigged, could attract salmon to unintended areas where escapement is not possible. This could actually reduce escapement compared to not using artificial light. In this regard, it would be worthwhile to do additional work with lights to help discern how to better prevent the light from bleeding into areas where it may not be helpful and could be detrimental to escapement.

Another important follow-up from the winter 2012 trials would be to do more testing to look at the question of whether tows with smaller amounts of Chinook per tow have inherently higher escapement rates than tows with relatively high numbers of salmon. The possibility that Chinook escapement rates are simply lower when high numbers of salmon are caught is worthy of evaluation as a standalone factor in understanding how to make excluders effective.

Finally, the results from the fall 2012 stage of testing with a completely new approach to chum salmon bycatch reduction were quite encouraging. This new chum-friendly design, referred to as the “over and under” or O/U excluder, allows salmon escapement out the top and bottom of the net. Initial results were approximately 20% chum salmon escapement with very low pollock escapement. Interestingly, the escapement opportunity on the bottom of the net accounted for only approximately a small fraction of the overall number of salmon escapes on the two test vessels in our EFP. It is therefore possible that for some reason the combination of the upper and lower components of the device changes water flow (or some other factor) that had previously limited chum escapement. It must be kept in mind, however, that testing conditions for the O/U excluder were not very representative of typical Bering Sea pollock fishing due to the September timing where pollock catch rates in the Bering Sea have tended to be rather low in recent years.

A very encouraging aspect of this new device is that this O/U excluder achieved the intended shape with minimal need for adjustments on two different vessels during our limited testing. This holds the prospect of more consistency in excluder shaping which could be important for eventually having an excluder that can be installed in a wider set of classes of pollock vessels (low vs. high horsepower) with less need for fine tuning.

Additional testing of the O/U device will be needed to answer remaining questions about the pollock and salmon escapement rates. As part of that work, hopefully a workable version of a recapture net can be installed on the bottom of the net so that the next set of tests can identify species of salmon for escapement more definitively. Finally, there is potential for this new excluder design to be at least as effective for Chinook salmon as the current flapper excluder given what we know about the swimming ability of Chinooks. A dedicated test during the winter months is needed to allow this to be evaluated. A new EFP would be needed for future work on the O/U excluder to be done using the same systematic testing methods used in this EFP.

Introduction

Salmon excluder designs have evolved considerably since experimental trials in the Bering Sea pollock fishery started in the fall of 2003. Design changes have been influenced by a suite of exempted fishing permit (EFP) tests and by feedback from fishermen using the various designs over the years since the EFPs started. This report details the latest performance testing under EFP 11-01 approved in 2010 with the objective of improving Chinook salmon escapement rates and finding a more effective excluder for chum salmon.

Specific objectives for EFP 11-01 were to: 1) Test in fall of 2011 whether the winter 2010 version of the flapper excluder would be more effective for chum salmon escapement than previous excluders which have generally been ineffective for chum escapement; 2) Test in winter 2012 whether the addition of artificial light to the area around the escapement portal of the flapper excluder would improve Chinook escapement rates; 3) Explore in fall 2012 whether modifications to the current design, including escapement portals at both the bottom and top of the net, would improve chum and/or Chinook escapement rates.

Because the objectives of EFP 11-01 varied over the three seasons, this report will describe each stage of fieldwork and results separately. First, a summary of findings from our previous salmon excluder EFPs in the Bering Sea pollock fishery is provided to give the reader some perspective on the evolution of the excluder designs.

Summary of excluder development prior to EFP 11-01

Initial work on the salmon excluder started in the fall of 2003 with the period from 2003-2006 focusing primarily on tunnel and funnel design excluder devices. These devices had different specific fundamentals but each was based on fast-tapered square-mesh panels to rapidly change the diameter of the net's intermediate section. This was intended to create an area with slower water flow above or around the square mesh section where salmon could get out of the flow of water/fish and escape out the top and sides. While the various designs at times produced promising Chinook escapement rates, square mesh panel excluders proved to be impractical for many Bering Sea pollock vessels due to their tendency to create bulges in the trawl and consequent net damage. Damage occurred from pollock becoming pinned at the entrance to the excluder. This problem tended to occur when pollock catch rates were high, a fishing opportunity most pollock fishermen were unlikely to forgo just to avoid damaging their excluder.

Experience with tunnel and funnel excluders led to a different focus in 2009 and 2010 -a shift to what are now called "flapper style" excluders. The directional change was, at first anyway, motivated in large part by the desire to avoid restricting the flow of fish through the net to the highest degree possible in order to eliminate the bulging and associated problems.

The starting point for the flapper design excluders was to use excluder panels that simply blocked access to a top escapement portal at normal towing speeds but allowed access for escapement when the vessel reduced its speed (Figure 1). This approach required periodic slowing of vessel speed for a sufficient duration to allow the panel to descend and salmon (and other escaping fish) to move forward and out of the top of the net (Figure 2). Typical reduction in vessel speed was from 3.5 or 4 knots to about 2 knots and duration was approximately 5 minutes at each slowdown. Slowdowns were conducted approximately every two hours for fishing conditions requiring longer tows.

Initial tests of this first flapper excluder design, however, resulted in relatively low escapement rates for Chinook. Additionally, many fishermen reported that the slowdowns themselves were not necessarily problematic in terms of impacts on fishing efficiency but the merits of an excluder requiring slowdowns were eventually questioned. The issue was that to conduct the slowdowns, fishermen had to retrieve the net slowly while the vessel speed was reduced thereby elevating the net in the water column. This could actually increase the time the net was located where salmon catches would likely be higher. Assuming this was the case, even if some of the salmon were able to escape, the net effect might be to effectively negate some or all the benefits of the device and possibly result in a net increase in salmon bycatch.

Figure 1. Initial Flapper excluder design (generation one).

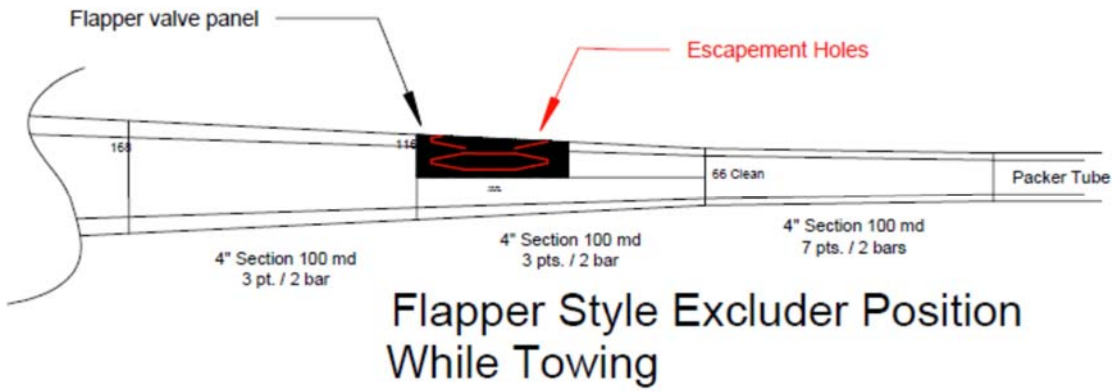
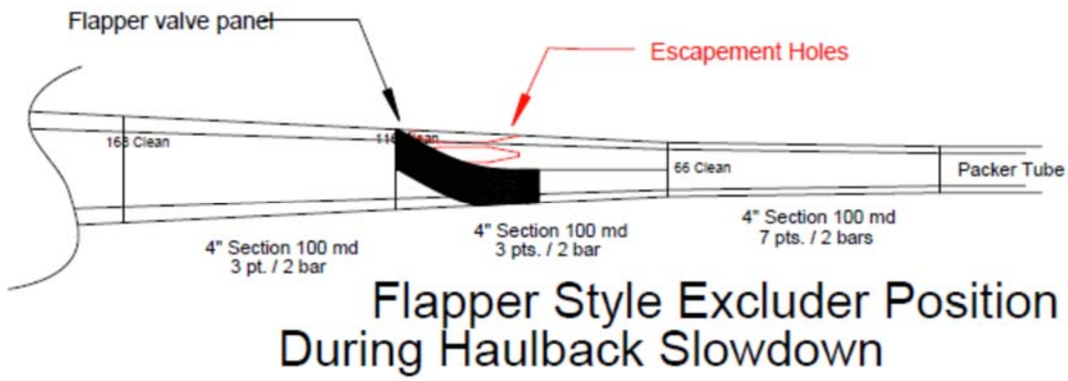


Figure 2. Initial flapper design at slowdown.



To address the problems identified with the first generation flapper, modifications were made to the design to continue to take advantage of the flapper's ability to accommodate high catch rates of pollock without net bulging while allowing for salmon escapement during normal towing operations. This was achieved by modifying the weight distribution on the flapper panel wherein instead of applying it evenly across the aft section of the panel it was concentrated in the forward section. The intent of this was to allow that section to sink down more effectively so that it would remain down to approximately half of the vertical distance of the intermediate during normal towing speeds. The rest of the flapper panel would trail back from the weighted section. This weighting scheme, in conjunction with the addition of an expanded hood at the top of the intermediate, provided salmon an adequate escapement pathway during normal towing operations with no required slowdowns.

This modified flapper configuration would still allow for large pulses of pollock to move through the excluder section, avoiding any bulge problems. If a large burst of pollock catch past through the excluder rapidly, the flapper panel would push up (flush with the top panel of the net) to restore the full diameter of the trawl's intermediate where the excluder was installed. Schematics of the second generation flapper excluder are shown in Figure 3 and Figure 4.

Figure 3. Side view of generation two flapper design.

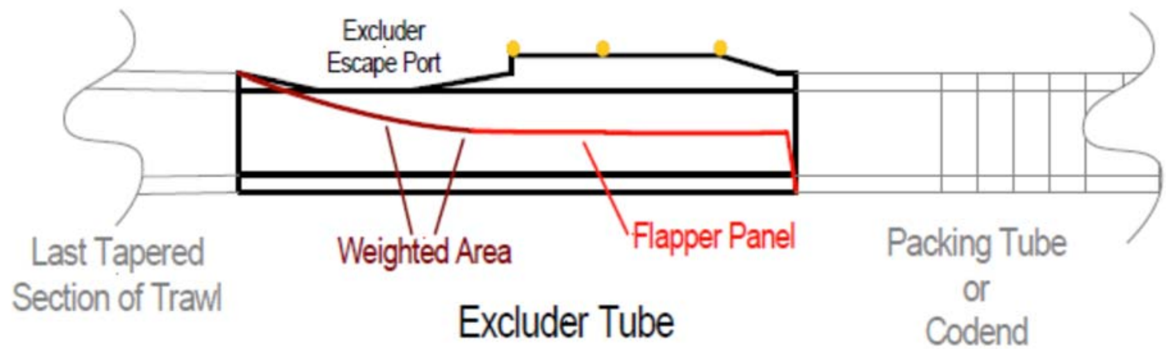


Figure 4. Functional schematic of generation two flapper style salmon excluder

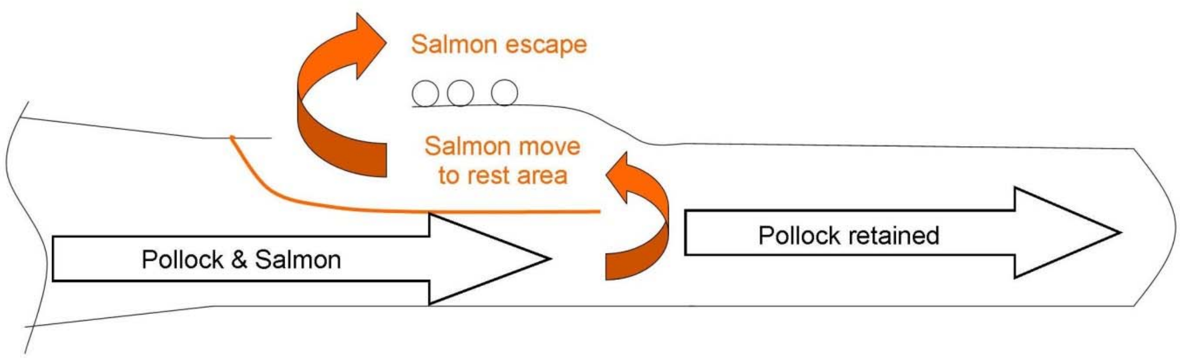


Table 1 displays salmon escapement rates for Chinook (winter tests) and chum (fall trials) for each stage of EFP 08-02. Chinook rates with the first generation flapper ranged from 8-16% (winter 2009 results in two phases of testing for one EFP vessel (P1 and P2) and a single test on the other) and jumped to 25-34% during the winter 2010 trials using the second generation flapper that allowed escapement during normal towing speeds (winter 2010 results for two EFP vessels). The 95% confidence intervals around mean escapement rates in winter 2010 were relatively narrow for these trials as well with pollock escapement well under one-percent by weight. Additionally, there were no bulge issues with the second generation flapper design.

In contrast, chum salmon escapement rates were low with the first generation design of the flapper (fall 2009 results in two testing phases) just as they have been throughout all stages of excluder development since 2003. Opinions for the poor chum escapement rates varied but there was considerable speculation that chums have less ability to swim forward against the flow and/or are less likely to utilize an escapement portal located at the top of the net (some fisherman believe than they tend to swim downward rather than up). EFP 08-02 did not allow for a test of the second generation flapper excluder for chum salmon escapement so one objective for EFP 11-01 to focus on chum escapement with the improved flapper design.

Table 1. Salmon escapement results EFP 08-02 (P1=phase I, P2=phase 2).

Test /date	Vessel	Codend salmon #	Recap salmon #	Salmon escape %
Winter 2009 P1	Pac Prince	726	91	11.1%
Winter 2009 P2	Pac Prince	1079	209	16.2%
Winter 2009	Starbound	720	70	8.9%
Fall 2009 P1 (chum)	Starbound	196	5	2.5%
Fall 2009 P2 (chum)	Starbound	643	34	5.0%
Winter 2010	Pac Prince	122	62	33.7%
Winter 2010	Starbound	150	49	24.6%

<u>EFP 11-02 Fall 2011: Evaluate the current flapper excluder design for chum salmon</u>

The flapper excluder rigging for the first phase of testing on chums in the fall of 2011 replicated as closely as possible the rigging of the excluder tested in the winter of 2010. The flapper panel was comprised of 3” knotless polyester webbing in the aft section and 4” knotted polyethylene netting and its forward section. The length of the panel was essentially equal to what it would have been with 100 meshes of 4” netting. The 100 meshes of 3” netting were sewn one-for-one to the 4” front section meaning the mesh counts across the flapper panel were the same for both the 3” and the 4” netting. That part of the panel was installed in the typical diamond orientation.

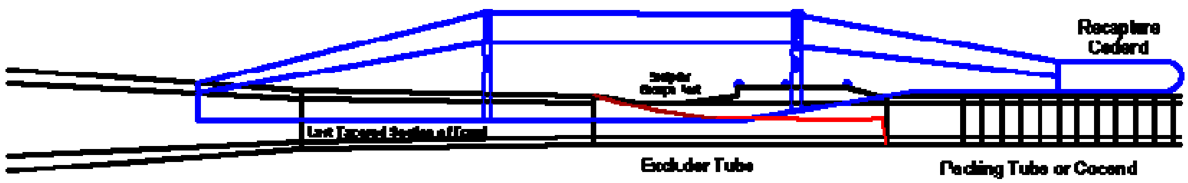
Weighting on the flapper panel totaled 160 lbs in the form of leadline strips oriented fore and aft attached to the forward section of the flapper panel (Figure 3). The leadline was cut into 10 lengths of the 8 lb. per fathom center-core leadline (approx. 8’ long). This type of leadline is typically manufactured with 2 braided covers over a lead core. To reduce drag, the outer cover was removed before installing it on the flapper panel.

To create the hood, six 8-inch hard plastic trawl floats were added to the webbing just aft of the escapement hole as shown Figure 3. These floats were arranged in two rows of three. The purpose of the hood was to create additional room for salmon to be able to swim forward above the flapper panel even when a large pulse of fish was pushing the flapper panel up towards the top of the net.

As in previous trials, a recapture net was used to measure escapement (number/quantity retained in the recapture net compared to total number which is number/quantity in the recapture net and codend combined). A diagram of the recapture net is shown in

Figure 5. The recapture net achieves its elevation above the trawl intermediate from lift provided by water kites and some supplemental trawl floats attached in two locations ahead of and directly aft of the escapement portal.

Figure 5. Net diagram showing excluder and recapture net.



Testing in the fall of 2011 occurred on the *Starbound*, a 240 foot factory trawler selected to participate in the EFP by an application review panel comprised of RACE Division personnel from the Alaska Fisheries Science Center. The *Starbound* had also been one of the two EFP vessels in the winter 2010 EFP so this provided an opportunity to reduce some of the variability that might otherwise result from inherent differences in the use of different test vessels. Under our EFP vessel selection process, vessels are not necessarily selected with preference to previous EFP experience but in this case the selection of one of the 2010 EFP vessels eliminated this “vessel effect”, allowing for an opportunity to better compare Chinook escapement rates across trials.

The catcher vessel *Destination* was initially slated to participate in these trials as well. Because the fall 2011 Chinook limit was very constraining (125 Chinook for two vessels) compared to previous EFP’s (Table 2, Table 3), the permit holder opted to cancel the *Destination’s* trial prior to its expected start date. This occurred because once *Starbound* started its test fishing, it was realized that Chinook salmon catch was occurring at unexpectedly high levels for the fall season when chum salmon is normally the only salmon taken incidentally in pollock fishing. Because the EFP had such a small allowance for Chinook in the fall season, it was decided that *Destination’s* test fishing would be cancelled to avoid all the costs of gearing up for testing with the possibility of the fieldwork having to stop prematurely (*Starbound* had already caught 53 Chinook of the 125 limit after only 2 days of fishing).

Table 2. EFP 11-01 initial salmon and groundfish limits by season

Season	Groundfish limit (mt)	Chinook limit (no.)	Non-Chinook limit (no.)
Fall 2011	2,500	125	2,500
Winter 2012	2,500	600	125
Fall 2012	2,500	125	2,500
Total	**7,500**	**850**	**5,125**

Table 3. EFP 08-02 salmon and groundfish limits by season

Season	Groundfish limit (mt)	Chinook limit (no.)	Non-Chinook limit (no.)
Fall 2008	2,500	2,500	5,000 no seasonal limit
Winter 2009	2,500	2,500	
Fall 2009	2,500	2,500	
Winter 2010	2,500	2,500	
Total	**7,500**	**7,500**	**5,000**

The fall 2011 testing on *Starbound* occurred September 14-27, 2011 in two phases. The first phase was comprised of 14 tows (930 mt groundfish catch) where the focus was to evaluate escapement of chum salmon (and Chinook as it turned out) as well as pollock with the same version of the flapper excluder used in the winter of 2010. The second phase (14 tows, 1,027 mt groundfish) included a small modification to the excluder panel: the removal of 20 meshes from the back section of the flapper panel. This was done to evaluate whether chum salmon escapement increased by reducing the degree to which the back edge of the excluder panel extended aft of the escapement hole.

Extension of the flapper aft of the back edge of the escapement hole is referred to as "overlap" in salmon excluder parlance. The term refers to the distance salmon would have to swim forward to access the escapement hole. The obvious tradeoff here is that at some level too little overlap would presumably result in large amounts of pollock escapement as well. From underwater video collected during past experiments, we know that pollock can swim forward in short bursts. From this we have assumed that reductions in overlap could result in increased pollock escapement, but this assumption had never actually been tested. Phase 2 testing was intended to help us learn how reducing overlap would affect both chum and pollock escapement.

The specifics of the changes to reduce overlap were as follows. During Phase One of the winter 2010 trial, the overlap was approximately 15 feet. The plan was to examine how well the Phase One test reduced chum bycatch and the related pollock escapement and then cut back the aft edge of the flapper panel accordingly. Since chum and pollock escapement were minimal during Phase I, we opted to make a moderate reduction in overlap (approximately 4.75 feet) with the removal of 20 meshes from the back edge of the flapper. A measured approach was adopted to avoid large amounts of pollock escapement which is particularly problematic for a recapture net test as well as industry buy-in for excluder use.

<u>Fall 2011 Phase I results</u>

Chum salmon escapement during Phase I was 11% (48 out of a total of 431 chums over 14 hauls) with a 95% confidence interval (calculated using MS Excel's resampling package with one-thousand resamples) ranging from 8.7% to 15.3% (Figure 6). This indicated some improvement over earlier trials but still a considerably lower rate than what had been achieved with Chinook salmon. Additionally, because escapement rates and numbers of chum per tow were reasonably stable over the EFP tows, the confidence around the mean result was tight and shows a range of results better than in previous tests with other excluder designs that focused on chum escapement.

Table 4. Fall 2011 EFP data by haul (F/T Starbound, Sept 14-27 2011).3 test tows not included (1.33 mt, one Chinook)

Haul No.	Total Catch (mt)	Catch Rate (mt/hour)	Avg. btm depth (fa)	Total Chinook (no.)	Total Chum (no.)	Chinook Escape Rate	Chum Escape Rate	Pollock Escape Rate
1	68.4	12.1	57	6	6	66.67%	16.67%	0.06%
2	99.0	16.5	52	18	125	38.89%	12.00%	0.41%
3	99.8	26.0	50	11	123	18.18%	9.76%	0.25%
4	44.8	7.5	51	17	76	47.06%	7.89%	0.20%
5	27.5	14.4	49	1	18	0.00%	5.56%	0.21%
6	69.8	26.2	45	2	2	0.00%	0.00%	0.28%
7	87.8	14.2	44	0	0			0.13%
8	32.5	6.2	50	0	0			0.47%
9	30.8	5.6	52	0	2			0.15%
10	84.4	16.1	56	0	0			0.20%
11	17.4	4.0	54	0	0			2.00%
12	92.8	14.5	50	0	2		50.00%	0.21%
13	95.1	11.4	51	0	65		18.46%	1.00%
14	80.1	8.1	56	0	12		0.00%	0.14%
Total Phase 1	**930.4**	**12.1**	**51**	**55**	**431**	**38.2%**	**11.14%**	**0.34%**
15	46.6	7.4	52	0	0			0.66%
16	9.0	6.0	70	0	100		12.00%	0.35%
17	52.3	11.0	70	0	182		9.34%	0.20%
18	93.2	22.4	70	0	205		0.98%	0.30%
19	101.1	13.5	71	0	26		7.69%	0.28%
20	86.1	16.7	70	0	53		1.89%	0.37%
21	94.0	13.4	71	0	851		7.05%	0.23%
22	100.1	11.2	71	2	101	0.00%	3.96%	0.34%

Haul No.	Total Catch (mt)	Catch Rate (mt/hour)	Avg. btm depth (fa)	Total Chinook (no.)	Total Chum (no.)	Chinook Escape Rate	Chum Escape Rate	Pollock Escape Rate
23	59.2	9.1	71	0	187		11.76%	0.26%
24	98.2	12.3	59	0	4		0.00%	0.23%
25	84.4	8.5	52	1	0	100.00%		0.10%
26	53.1	8.3	53	0	2		50.00%	0.52%
27	40.3	7.6	57	0	20		15.00%	0.54%
28	109.7	11.3	52	0	3		33.33%	0.36%
Total Phase II	**1,027.3**	**11.3**	**64**	**3**	**1,734**	**33.3%**	**7.21%**	**0.31%**
Season Totals	**1,957.7**	**11.6**	**57**	**58.0**	**2,165.0**	**37.3%**	**7.99%**	**0.32%**

Figure 6. EFP 11-01. Percent salmon escapement with 95% CI's by EFP segment and salmon species where appropriate

The pollock escapement rate in Phase One was also quite low (0.34%). This rate is comparable to that obtained in winter of 2010 testing with the same excluder device and test vessel. The 95% confidence interval was 0.2% to 0.6%. This was also quite similar to the confidence range seen in 2010 result when testing focused on Chinook escapement.

One unanticipated aspect of the fall 2011 fieldwork was that the location for the Phase One testing (east of the Pribilof Islands) afforded a unique opportunity to evaluate the winter 2010 version of the flapper excluder for both chum and Chinook escapement simultaneously because both species were being caught. Unfortunately, our EFP was issued only a small allowance for Chinook catch for the fall of 2011 (Table 2) so even at the low catch rates per tow (relative to chum salmon), the field personnel had to keep close attention to how many Chinooks were taken along with the chums to avoid attaining the limit of 125 Chinook which would have stopped the project before both phases could be completed.

While Chinook catches in the Phase One testing of the EFP (55 salmon) were not large relative to what is has normally been encountered in our EFP testing in winter, the small but steady numbers of Chinook per tow offered an opportunity to see if the fall 2011 Chinook escapement rates would be similar to winter 2010 trial. Accordingly, the Chinook escapement rate for the Phase One test was 38% (21 out of a total of 55) with the 95% confidence intervals ranging from 24% to 50%.

While not necessarily a confirmation of the escape rate seen in winter 2010, achieving escapement rates in this range was seen as a very positive sign. Additionally, the opportunity to test the excluder for Chinook and chum simultaneously lent further credence to the idea that chum behavior in a net as it relates to use of an excluder may differ from that of Chinook.

Fall 2011 Phase 2 results

Following Phase 1, the back edge of the flapper panel was shortened by 20 meshes thereby reducing the overlap by about 30%. To avoid risking curtailment of the EFP due to early attainment of the limit placed on Chinook salmon, the EFP vessel relocated to west of the Pribilof Islands and later all the way up into the Bering Sea canyons. The pollock industry's bycatch avoidance program's information on bycatch rates indicated these areas would have very few Chinook salmon but considerably higher chum salmon catch rates. Pollock catch rates per hour were expected to be higher in the new locations as well.

The expectations for catch rates in the new locations proved to be accurate for chum and Chinook salmon with chum catch rates per ton of pollock approximately four times higher and nearly no Chinook in the new locations. Pollock catch rates were, on average, slightly lower (12 mt/hr compared to 13 mt/hr in phase I).

The expectation that chum escapement would increase with the shortened flapper was not realized. Chum escapement averaged only 7% (95% CI 4-10%Figure 6) in Phase Two (125 out of 1,734 chum escaped). While lower than the chum escapement rate in Phase One, the values within the 95% confidence intervals overlap considerably indicating that there is unlikely to be any statistically significant difference between the rates. The Phase Two results may actually be a better indicator of chum escapement with the flapper excluder (whether full length or shortened) because the second phase of testing encountered a much greater number of chum salmon over the 14 tows.

Pollock escapement in the second phase was also 0.3% with the 95% confidence intervals from 0.2 to 0.4. The reduction in overlap did not appear to have any significant effect on pollock escapement.

Given these results for chum and pollock, the question arises as to what we can say about how reducing the amount of overlap affects escapement. One possibility is that reducing overlap would increase escapement (of chums and/or pollock) but we did not reduce it enough or enough to detect a difference. Alternatively, it may be that reducing overlap will not achieve the desired effect in terms of increasing chum escapement because something other than the distance that chums would have to swim forward against the flow is not what is affecting chum escapement (e.g. chums are resistant to swimming out of an escapement hole on the top of the net). Unfortunately, we have no way of answering even the first question because our groundfish catch allowance for the Fall 2011 trial did not allow for further testing.

Regarding the industry's concerns over how pollock escapement might increase with reduction in overlap, it appears these were not realized. One has to keep in mind, however, that this result is probably only really applicable to a higher horsepower boat like the Starbound where water flow through the net is optimized given the higher towing speed. Our video observations during this second phase of testing did appear to show that pollock that attempted to escape were able to make it closer to the escapement hole than they appeared to with the longer flapper panel. It is therefore possible that a boat with lower towing force and lower net spread/water flow might incur more pollock loss than was seen in this test. At the same time, the limited video obtained did not indicate any positive effect on chum salmon escapement (in fact a lower rate, nominally, was achieved) relative to the Phase One test so there may not be any upside in terms of chum salmon anyway to reducing overlap and at the same time there may be a downside for some vessels with reduced overlap.

Winter 2012 test of the current flapper device with light added to increase Chinook escapement

The objective in the winter of 2012 was to evaluate whether the addition of artificial light would augment Chinook escapement above the levels seen with the same excluder in the winter of 2010. The genesis of this objective was input from captains conducting the winter 2010 testing. At the conclusion of the test, the question was posed as to what changes to the excluder they would like to examine to increase escapement. In this context, the captains came up with the idea of adding artificial light to the area above the escapement hole.

It is important to recognize that since the outset of this project (since 2003) the use of artificial light has been rigorously avoided in underwater camera placements during EFP testing under the assumption that it could influence fish behavior. We therefore had very little in the way of knowledge in terms of changes to fish behavior that would occur when lights were added. When asked why they were interested in adding light, the EFP captains explained that they expected salmon would be attracted to the light and they felt escapement rates were higher in the daytime tows of the 2010 EFP. While daytime escapement was higher for that specific test, the reverse had been the case in past EFP testing with other excluder designs. Additionally, winter fishing in the Bering Sea occurs mostly under conditions of fairly limited natural light, particularly at typical winter fishing depths (> 100 meters). For this reason, the effect of light was not straightforward in their observation that daytime escapement rates were higher.

In considering the issue of how ambient or artificial light may affect fish behavior in the excluder trials in winter 2011, the larger issue of unknowns became evident with respect to how pollock or salmon use light as they navigate through the net or how it affects their response to the excluder. Our strict use of low light cameras without adding artificial light in our fieldwork had frankly left us "in the dark" regarding such simple considerations such as how bright artificial lights appear at typical fishing depths.

Lacking prior video observations to determine how light affects fish behavior, we decided to look to the lowest common denominator in terms of what we did know from our previous tests. The most basic information we had was that salmon escapement occurs in both daytime and nighttime conditions and that rates were variable with no clear correlations. From our use of cameras with sensors designed to work with low levels of light we also knew that tows done during non-daylight hours did not have enough ambient light for any useful video, nor did daytime tows deeper than 120 meters. From this we deduced that salmon can find their way to the excluder's escapement portal with levels of light that are lower than what is required for video with low-light camera lenses.

From this we theorized that adding artificial light to the area around the excluder could increase escapement if salmon are attracted to light as the captains had assumed but had little more than intuition regarding how much light would be the right amount. The methods for placing the light in manner that would be effective were not clear as well. To look at this issue, one approach would be to aim the light above and out of the escapement portal and not back into the net where the excluder was installed. This made sense because light shining down into the net might actually entice salmon to remain in the net if they were attracted to light. Another approach would be to evaluate whether a lighted pathway might increase escapement of salmon under the assumption that they might be able to navigate their way out of the net more effectively.

Given that both of these approaches were worthy of testing, both were adopted into our testing plan as separate tests - one for each EFP vessel. Ideally, one would test both light configurations on each EFP vessel in a controlled experiment but this was not possible given the limits on groundfish and salmon. As was explained in the EFP application, our examination of whether light would increase escapement was therefore essentially a "pilot study" approach that would hopefully provide some information but was not expected to result in any definitive answers.

One final part of this included the recognition that using light with a recapture net was potentially different from how light might affect escapement without a recapture net. This is because the recapture net material reflects the light in an area outside of the escapement portal, a condition which would not exist in the regular fishery. In the event that having a surface outside the escapement portal to reflect light was needed to make the addition of light effective for increasing salmon escapement, captains and crews were asked to think how something could be done in the future without a recapture net. This would be important if attraction to light did show promise for increasing escapement and one wished to mimic the effect in the regular fishery without using a recapture net.

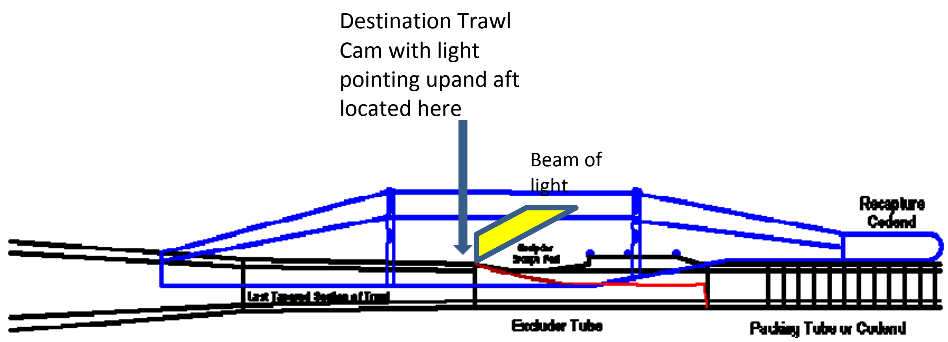
Specifics of winter 2012 testing to evaluate effects of artificial light added to the flapper excluder

In addition to the *Starbound*, the *Destination*, a 180 foot catcher vessel participated in the winter 2012 trials. These vessels were selected by an application review team from the Alaska Fishery Science Center and both vessels had extensive experience with EFPs. Prior to adding artificial light, both vessels started with the flapper excluder as rigged for the fall 2011 Phase One testing (prior to cutting back the flapper panel by 20 meshes to reduce overlap). Video observations in mid-water tows were done just prior to the EFP on each vessel to confirm that the flapper panels for both excluders were achieving the desired shape and to verify that each flapper panel was hanging down approximately half of the vertical height of the trawl intermediate at normal towing speeds.

The *Destination* was selected for the simpler test to evaluate whether light attracted salmon and increased escapement rates by aiming light outside the escapement hole. The lighting supplied for the test was from the vessel's 'trawl cam' system. This is an integrated camera/ recorder/LED light system with a steel frame that houses all three components. Floatation was added to the trawl cam system to achieve neutral buoyancy.

The light in the *Destination*'s trawl cam system was a wide-beam LED light achieving 900 lumens. To project the light out of the escapement hole, the underside of the trawl cam frame was attached to the top of the trawl intermediate (inside the recapture net) at the forward edge of the escapement hole. The camera system faced aft with the light aimed up and back (Figure 7). The use of the trawl cam to provide the light instead of a stand-alone light was selected to take advantage of previous experience with installation of the camera system in a manner that would provide a relatively stable base for the lighting.

Figure 7. Destination net with excluder and light configuration.



The plan for the *Starbound* was also to use their trawl cam to light the area above the escapement hole in the same manner and to use multiple smaller lights to lightthe pathway from the rear to the escapement hole. The smaller lights used were "Lindgren Pittman" pressure activated "swordfish" LED lights. These self-activating lights were attached individually to the flapper panel with cable ties and reflectors to direct the light in one direction. The lighting of the escapement pathway amounted to 15 of the swordfish lights evenly spaced along the center line of the top of the flapper with the lights projected upward. To help prevent light from shining down below the flapper panel (assuming this might attract salmon to an area underneath the flapper where access to the escapement panel was not possible), strips of plasting backing sheets were attached to each swordfish light. An additional 3 lights were placed close together at the aft end of the flapper with the light projected downward to light up the slower water area at the back edge of the flapper panel(see Figure 8 and Figure 9).

Figure 8. Schematic of light distribution pattern on flapper panel, *Starbound,* winter 2012.

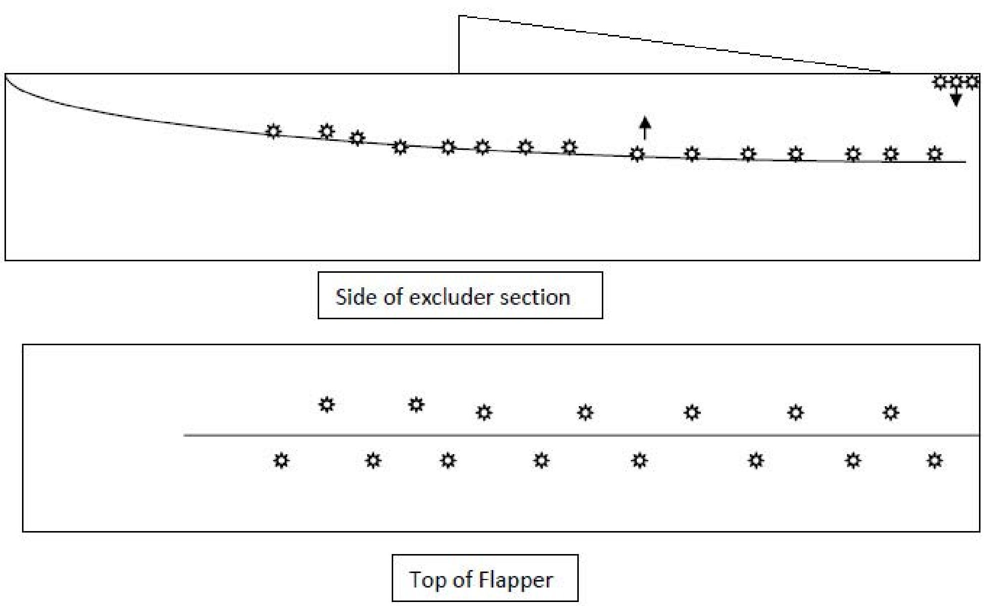


Figure 9. Lindgren-Pittman (swordfish) LED light.

Based on the manufacturer's estimate of battery capacity for the swordfish lights, the batteries would be replaced approximately half way through the excluder test on the *Starbound* to ensure that the pathway would remain lighted for each tow.

An additional camera without lights was used to observe the lighting and any fish behavior for both EFP vessels throughout the trails.

Field trials on the *Destination* were conducted from February 15-23 (18 tows, 1,280 mt groundfish). Fishing depths ranged from 115 to 290 meters with an average towing depth of approximately 200 meters.

Starbound 's testing occurred from February 11-17 (17 tows, 1,250 mt groundfish). Fishing depths ranged from 100 to 320 meters with an average towing depth of 205 meters.

<u>Winter 2012 Results:</u>

The *Destination*'s testing occurred in locations north of Unimak Pass where the pollock fishery had encountered relatively high Chinook bycatch rates prior to being closed under the rolling hotspot bycatch avoidance program. Following a set of video tows to evaluate how the lighted recapture net appeared at fishing depths, the EFP tows were started. The testing comprised 18 EFP tows during three dedicated EFP trips. Overall, Chinook catch rates were highly variable with the majority of the overall Chinook catch occurring in a single tow (Haul 3, 170 of a total of 223) and much lower Chinook catch rates for the remaining hauls (0-10 salmon per tow). Across all the EFP tows, the Chinook escapement rate for *Destination* was approximately 14% (31 out of a total of 223) with an associated 95% confidence interval from 10.5% to 34% (Figure 6 and Table 5).

This overall result for Chinook escapement was clearly driven by the low escapement rate on the tow with the high number of Chinook. That tow had an escapement rate of only 11% (19 out of 170).

Pollock escapement averaged 0.41% with the 95% confidence interval ranging from 0.13 to 0.78.

Table 5. EFP 11-01 Destination Winter 2012 data.

Haul No.	Total Catch (mt)	Catch Rate (mt/hour)	Avg. btm depth (fa)	Total Chinook (no.)	Chinook Escape Rate	Pollock Escape Rate
1	80.94	11.04	57	1	0.00%	0.26%
2	88.65	118.21	74	0		0.06%
3	90.26	16.92	145	170	11.18%	0.11%
4	65.40	31.39	77	3	0.00%	0.20%
5	8.58	3.81	82	1	0.00%	0.08%
Trip 1	**333.83**	**18.81**	**87**	**175**	**10.86%**	**0.15%**
6	134.66	101.00	81	2	0.00%	1.86%
7	65.05	65.05	88	2	50.00%	0.45%
8	73.97	59.18	92	2	0.00%	0.24%
9	2.42	14.54	100	0		0.00%
10	81.60	27.20	104	3	33.33%	0.07%
11	88.50	27.23	108	3	66.67%	0.17%
12	63.40	76.08	112	1	100.00%	0.21%
Trip 2	**509.60**	**47.04**	**98**	**13**	**38.46%**	**0.65%**
13	89.79	41.44	125	9	0.00%	0.06%
14	77.67	56.15	130	6	50.00%	0.07%
15	21.82	52.37	79	3	0.00%	0.40%
16	70.43	76.84	110	5	20.00%	0.02%
17	76.11	23.42	112	6	50.00%	0.07%
18	101.28	86.81	138	6	0.00%	1.18%
Trip 3	**437.11**	**47.00**	**116**	**35**	**20.00%**	**0.33%**
Total	**1280.53**	**33.80**	**101**	**223**	**13.90%**	**0.41%**

The low Chinook escapement rates begged the question of whether the addition of artificial light had any positive effect or possibly even had negatively affected escapement. The fact that a very high proportion of the salmon catch occurred in a single tow complicates our assessment of these results. Given that the average escapement rate for the other tows (25% without tow 3) was in the range of expectation for the device (without the addition of light), it's possible that the poor escapement rate for haul 3 simply overpowered the results for Destination. Ideally, another test under the same conditions without light was needed to observe any differences in the rates. Unfortunately, there was not sufficient groundfish or salmon available to allow for further testing. Additionally, although the flapper excluder design and rigging matched what was used in the earlier tests, the test vessel in this case was a different catcher vessel from the one used in the winter 2010 so the possibility of a "vessel effect" on the results cannot be dismissed.

The *Starbound* 's EFP testing was done in the same general area as Destination's although some tows were done in the deeper, more off-shelf waters further west. Following a set of video tows to verify that the lights were working and desired lighting scheme was achieved, the *Starbound* made 17 EFP tows. While the majority of Chinook catches occurred over more than a single tow, 4 of the 17 tows accounted for the vast majority of the Chinook catch (accounting for 206 of the 236 total catch). Chinook numbers for the other tows ranged from nine tows with zero Chinook and four with 1-15 Chinook. The *Starbound* 's overall Chinook escapement rate was 11% (26 of 236) with the 95% confidence intervals ranging from 6% to 25%. See Table 6.

Similar to what was seen on the *Destination*, the *Starbound* had low escapement rates on the tows where most of the Chinook salmon were caught (5% to 14% escapement per tow). For tows with lower Chinook numbers, escapement rates on a per haul basis were at times around 40%.

Pollock escapement rate for the *Starbound* averaged 0.2% with a 95% confidence interval of 0.1 to 0.4%.

Table 6. EFP 11-01 Starbound winter 2012 data.

Haul No.	Total Catch (mt)	Catch Rate (mt/hour)	Avg. btm depth (fa)	Total Chinook (no.)	Chinook Escape Rate	Pollock Escape Rate
1	102.98	41.19	170	5	0.00%	0.02%
2	82.71	17.00	177	15	46.67%	0.13%
3	6.35	3.81	158	9	44.44%	2.88%
4	78.56	47.13	144	42	7.14%	0.01%
5	78.79	51.39	145	33	9.09%	0.03%
6	71.71	78.23	112	28	14.29%	0.66%
7	105.43	64.55	110	103	4.85%	0.01%
8	73.91	46.68	69	0		0.24%
9	81.99	98.39	67	1	0.00%	0.01%
10	70.65	40.37	65	0		0.00%
11	58.15	24.92	67	0		0.05%
12	107.09	107.09	51	0		0.01%
13	64.08	15.38	55	0		0.15%
14	63.57	152.57	55	0		0.35%
15	75.10	29.07	57	0		0.35%
16	91.85	61.23	57	0		0.46%
17	39.11	234.65	59	0		0.18%
Total	**1252.02**	**40.13**	**95**	**236**	**11.02%**	**0.17%**

As with *Destination*'s overall results, the explanation for why Chinook escapement was lower with artificial light is not clear. But some possible explanations can be offered. For the *Starbound*, most of the Chinook catch occurred in a roughly one-fourth of the tows and rates per tow for these were quite low. On balance, however the escapement rate for a single tow did not effectively determine the overall outcome as was the case for *Destination and Starbound's* result was driven by a considerably larger fraction of the hauls (roughly one-fourth). In past experiments, we have been more comfortable accepting results that arose from that kind of proportion of EFP hauls recognizing that salmon bycatch rates per tow are always going to be variable even if testing occurs inside salmon hotspot areas. From this perspective it is harder to attribute the low escapement result for *Starbound* as driven by the chance outcome that a very small number of tows with low escapement rates caught a large fraction of the overall Chinook catch in the EFP. Additionally, potential for a "vessel effect" was not a consideration for interpreting the difference because *Starbound* was one of the EFP vessels in the 2010 test (escapement rate of 24% then and 38% in the fall 2011 testing).

In reviewing the possible explanations for the low escapement results with the addition of light, one possibility is that lower escapement rates tended to occur on tows with lots of salmon and higher rates on tows with lower numbers. Looking back to the winter 2010 results, the relatively high escapement rates achieved at that time occurred with consistent but fairly low numbers of Chinook caught per tow. There were in fact no other tests with this excluder device that encountered a high proportion of the salmon in the test in one or a small proportion of the test tows. For this reason, the possibility cannot be dismissed that this excluder design, with or without light, does not perform as well for hauls when large numbers of Chinook are caught. The reason why the excluder would not work as well for tows with high numbers of salmon is not clear at this time. In reviewing our results over the course of EFP testing with flapper devices, some fishermen have stated that the device would not be as likely to perform well on tows with high pollock catch rates. This is plausible because high catch rates of pollock could serve to block access to the escapement hole. As for why large catches of salmon would reduce performance, no persuasive explanation has emerged.

Another possibility is that the addition of artificial light did negatively affect escapement rates and for some reason this may have had a bigger effect on tows with high numbers of salmon for some unknown reason. To examine this possibility, we looked to the video footage from the test with this in mind. While we were able to get video observations on both vessels, we obtained far more on the *Starbound* due to some equipment problems on the *Destination* so most of information below comes from *Starbound's* footage. On that vessel, the lighting was far brighter than what we anticipated even if our expectations for light brightness at fishing depths were based on little more than a guess. Part of the discovery that lights were brighter than we had envisioned is probably explained by the use of low-light lenses on the cameras to look at our lighting arrangements.

But another part of the story is the lack of any ambient light at the fishing depths even during daytime tows. Noting the degree of brightness in the test tows, we agreed that this was not especially problematic for the trawl cam lighting designed to project out of the escapement hole - as long as the light did not illuminate inside the intermediate there would not be much downside to extra brightness. If the light penetrated back into the intermediate, however, we were concerned it could potentially negatively affect escapement. This is because if salmon are attracted to light, they would encounter the light before reaching end of the flapper panel where access to the escapement hole became available.

From the camera placements done in the pre-EFP tows, however, it became clear that no matter what we did to prevent it, the trawl cam light did bleed down through trawl intermediate. Hence the excluder pathway and trawl intermediate itself were illuminated on F/V Destination which was not what we had intended. This was surprising given that the housing of the trawl cam system was expected to shade below the unit. Attempts were made to aim the lights at angle that would reduce the chance of illuminating the area below the lights but nothing was actually fully successful in this regard. This can be seen in the picture below where the brightness of the light that was supposed to project out of the escapement hole on the *Destination* can be seen in Figure 10 and Figure 11. The first photo (looking aft) shows the hood at the top of the excluder at the entrance to the recapture net which is illuminated to a far larger extent than we intended. The second shows a group of Chinook salmon swimming in the recapture net -the light hitting them is aimed more than a meter away from where these fish are located.

Figure 10. Destination trawl cam projecting light into the recapture net and down into the intermediate (looking aft).

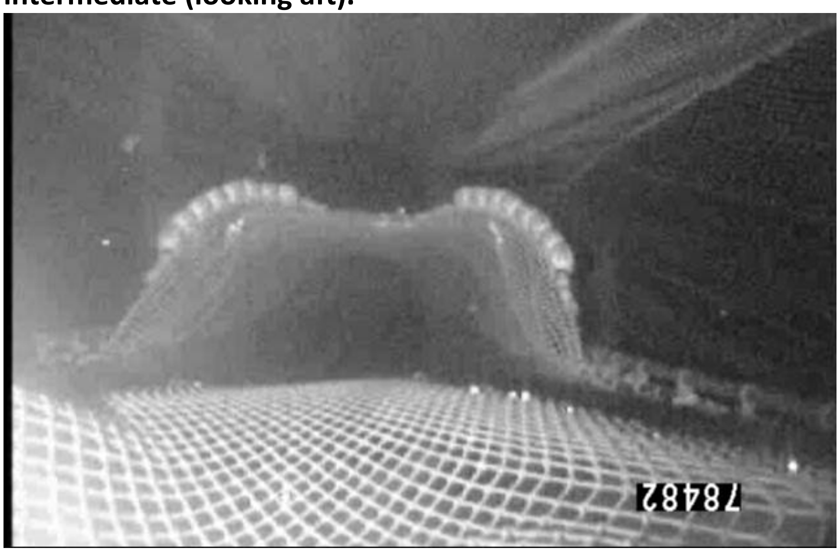
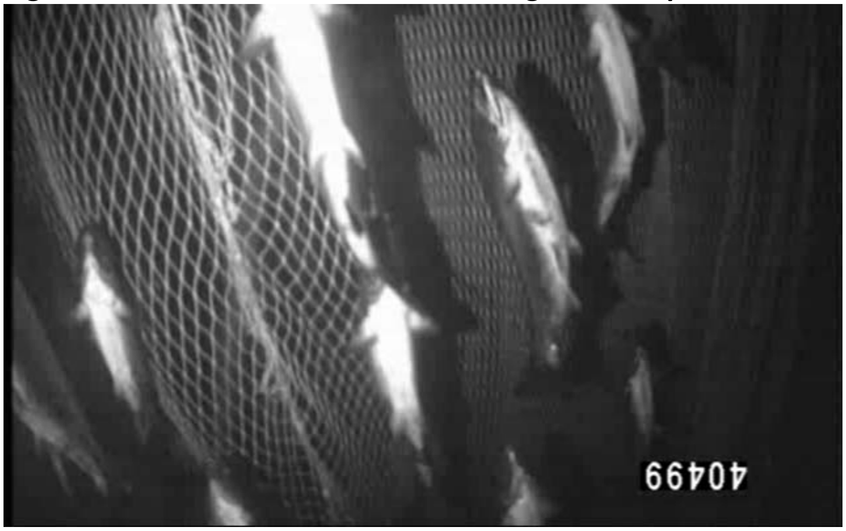


Figure 11. Destination trawl cam looking further upward at the top of the recapture net.



Video footage from the *Starbound* also revealed very bright lighting. In selecting the swordfish lights, it was noted that these barely produce enough light for a human with good vision to read large text in close proximity to the lights in a dark room. For this reason, we were surprised to see how bright they appear in our video footage. Also, as with *Destination*, the trawl cam light illuminating the area above the escapement hole on the *Starbound* was very bright. During the pre-test tows on the *Starbound* we decided that the overall amount of light generated by the trawl cam light in combination with the swordfish lights was simply too great. To address this, the lower portion of the trawl cam light elements were covered to reduce the brightness and to help prevent the light from bleeding down into the trawl intermediate.

Figure 12 below shows that despite this reduction in light focused above the escapement hole on *Starbound*, the brightness and degree that the area was illuminated remained quite large. Figure 13 shows how bright the swordfish lights appear at fishing depth. As was mentioned above, plastic backings on the swordfish lights were installed to help shield the light from penetrating under the flapper. This was deemed to be accomplished in the pre-trials based on views from under the panel even if our overall feeling was that the swordfish lights seemed far brighter than we had hoped they would be.

Figure 12. Views of hood and recapture net on Starbound. Swordfish lights (on top of the flapper) can be seen in the distance (top photo).

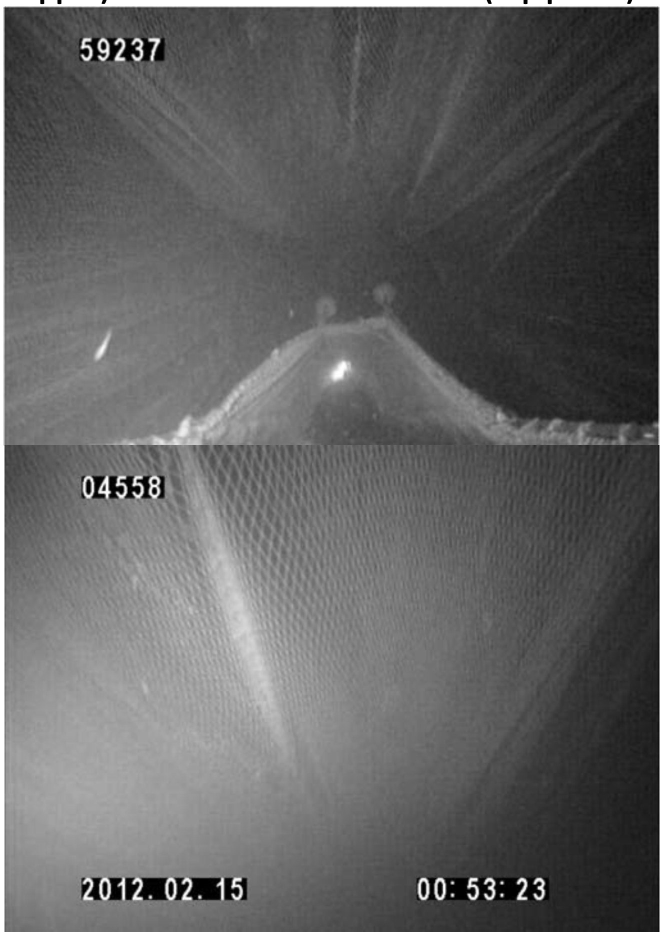
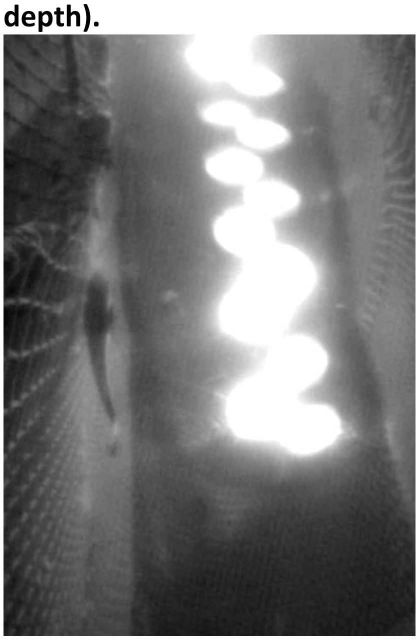


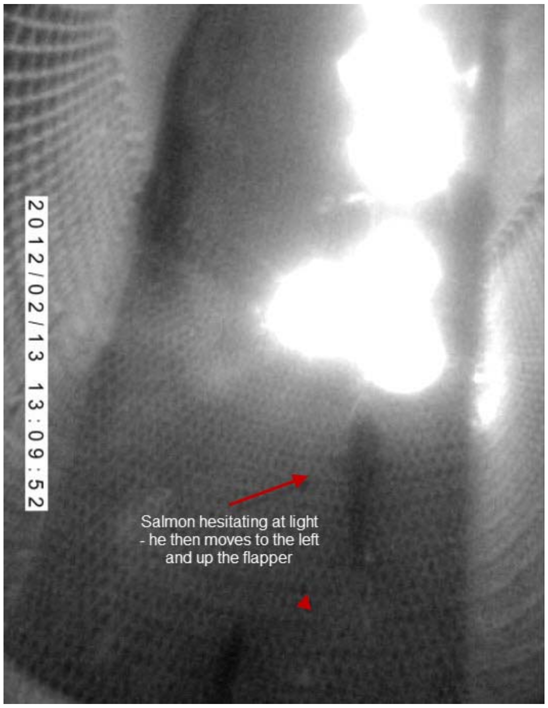
Figure 13. Swordfish lights on the Starbound flapper (looking forward from the codend at depth).



One final insight from the *Starbound* video was that some salmon moving up the lighted flapper panel escapement pathway were observed to stop and remain in the area where the first set of lights was installed.   This can be seen in Figure where a salmon is “parked” in the area where the lighted pathway begins. The video shows that this fish remained in this area for quite a while and returned to it after moving forward and then finally moving up the panel and outside of the visible range of the camera.

The attraction of salmon to the swordfish lights was observed on only a limited number of occasions because most of our video deployments were located above the escapement hole. Given our low number of camera deployments in this area, we cannot fully assess how often it occurred. In any case, available observations suggest that attraction to light may be important for salmon moving through the excluder section. In this context, a lighted pathway at least as was done in our experiments on the *Starbound* could actually confound escapement rather than augment it.

Figure 14. Starbound lighted flapper with salmon hesitating at light.



In summary, the video observations do not provide any definitive explanation for the low escapement rates but do provide some possible factors to consider. One is that using light as an attractant is more difficult than we anticipated. In this regard, it would be worthwhile to do additional work with lights to help discern how to better prevent the light from bleeding into areas where it may not be helpful and could be detrimental to escapement. This assumes that light is an attractant and affects escapement which is somewhat suggested in the video observations but this issue is far from resolved. This is where being able to test with and without light would have been important but we did not have sufficient groundfish to do a follow-up test without the lights. Another important follow-up would have been to do more testing to look at whether tows with smaller amounts of Chinook per tow had higher escapement rates than tows with lots of salmon. The possibility that Chinook escapement rates are simply lower when high numbers of salmon are caught cannot be dismissed. Given the limits on our testing, this was also not possible.

<u>Fall 2012: New innovative design (called the "Over and Under" excluder) for chum escapement</u>

Given the disappointing results from the fall of 2011 tests for chum bycatch reduction (with and without the reduction in overlap), the focus for fall 2012 turned to a new approach that would address the shortcomings related to flapper excluders and chum salmon escapement. This new direction involved designing an excluder that allows for escapement from the bottom of the net without letting large quantities of pollock out of the net. While there was no definitive evidence that the relatively low chum escapement with past excluders was due to an inherent behavioral difference with chum salmon, after repeated tests with generally low success despite adjustments to make escapement out the top easier, the possibility that the low chum escapement was due to behavioral differences certainly pervaded the thinking of everyone involved with the question of where to turn next to address chum bycatch reduction with excluders.

The task of coming up with an excluder design to accomplish escapement out the bottom was shouldered by John Gruver as part of his gear design role for this project since 2003. Mr. Gruver's approach was to make use of the concept of the flapper but to utilize the concept in both the top and bottom of the net. Located in the last tapered section of the trawl, the new design incorporates two escape routes that are mirror images of each other. Rather than adding flapper panels to the device, the new designs utilizes the existing top and bottom net panels to serve as "flappers"; the upper panel is weighted towards the center of the net while the lower panel is floated towards the center. Escapement portals are cut into the aft end of the top and bottom panels as well. Large hoods, similar to the flapper excluder hood, are attached over the upper and lower escapement portals. The upper hood is floated upwards to open it and the lower is weighted to "sink it open" as well.

Rigged as such, fish coming back through the net would pass between the panels and once behind them could swim forward in the slower water and access the escapement portals on either the top or bottom (hopefully only salmon would be able to do this). The hoods will take a "scoop" shape that, in combination with water flow, weight, and floatation, would provide relatively large cup-shaped escapement pathways out of the trawl.

As a starting point for this concept, Mr. Gruver made a half scale model of the Over and Under conceptual design. With this model, work began in a flume tank facility in Memorial University in St. Johns, Newfoundland in the fall of 2011. At that time, approximately three days were spent investigating ways to take the "Over/Under" concept from a rough design to a well-shaped device. This involved refining taper cuts in the hood netting and escape portals, adding and removing netting in strategic areas, and adjustments to floatation and weighting so the excluder design was ready to be built at full scale and tested in the field trials.

Locating this over and under (O/U) excluder design in the tapered section was intended to help prevent unacceptable Pollock loss. The reasoning here was that in earlier work we noted that the much stronger water flow in the aft tapered sections generally resulted in low pollock escapement. Figure 15 illustrates the O/U excluder concept developed in the fall of 2011. Figure 16 is a photograph from the flume tank work of a half scale model of the device using floatation and weight (chain instead of leaded line). See also Figure 17, underwater view of full scale O/U excluder taken during the field trials in B Season 2012.

With the two escapement pathways located one on top of the other, salmon moving to the back of the net would be shunted into the center thus providing them a section of slower water flow where they could react according to their instinctive preference for escapement (top or bottom). If a large burst of pollock was moving down the net, the upper and lower panels would push up (for the top panel) and down (for the bottom panel) to accommodate the large amount of fish. This would avoid the problem of pinning fish and creating a bulge in the net as was seen in earlier efforts on excluders.

All attendees at the flume tank who worked on this design thought that it would be important to build a full scale version of this excluder and evaluate it in the field. Expectations for what would happen when it was "put in the fish", however, ran the gamut from massive pollock escapement out the bottom to low pollock escapement due to the location of this excluder in the tapered section. Many on both sides of the pollock loss expectation debate thought, however, that salmon escapement (both chum and Chinook) would be improved. A few captains even said they were ready to put this new device in their net in preference to the flapper excluder as soon as some field testing was done to verify that the two panels could achieve the desired shape on a consistent basis.

Figure 15. Conceptual schematic of the Over and Under excluder

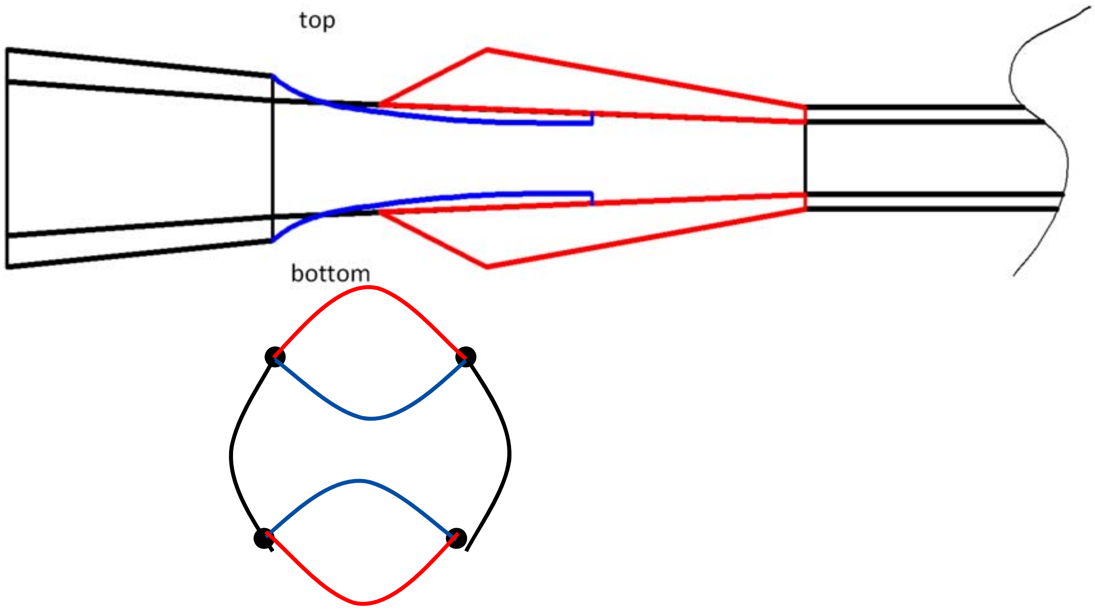


Figure 16. Flume tank model of the Over and Under excluder

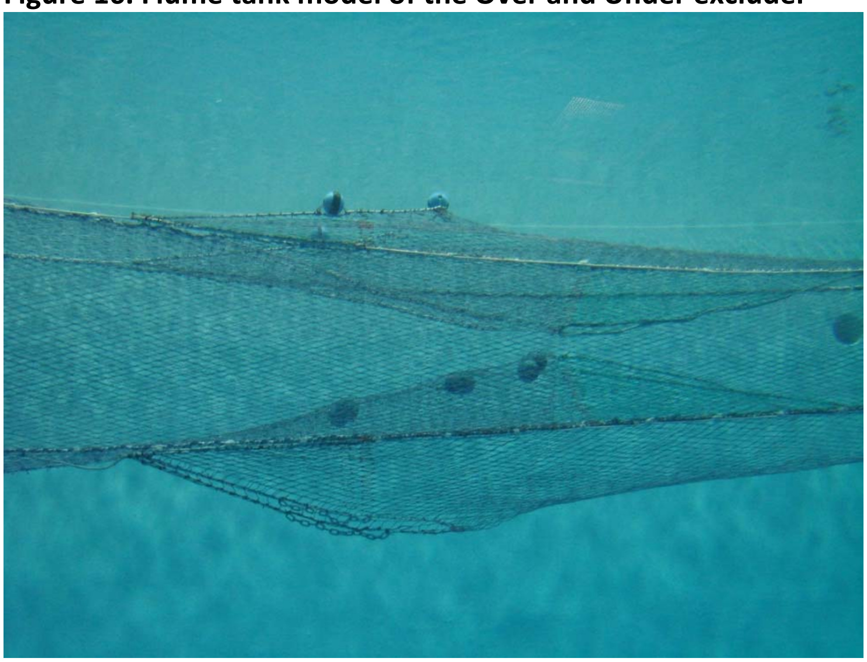
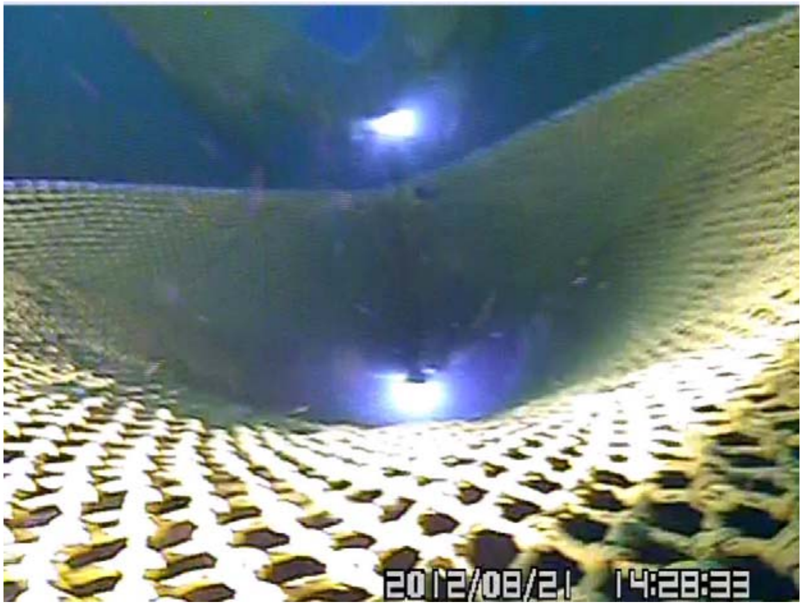


Figure 17. Top and bottom excluders (over/under)



One can see from the conceptual drawing in Figure 15 that the upper webbing panel (in blue) functions much like the flapper panel attached to the top section of flapper excluder that was the focus of winter 2012 EFP testing. Fish passing through the net (left to right in the figure) should only be able to access the escapement hole at the top of the intermediate (in black) by swimming forward above the top panel. Leaded line attached to the upper panel holds it down so that it remains approximately half way down the intermediate at normal towing speed. The upper hood (in red) provides additional room for escaping fish where they can swim up and forward out of the flow of target fish that is moving backward through the net. Floatation on the sides of the front portion of the hood is used to create the shape of the hood as shown.

The bottom portion (also in blue) of the O/U excluder is based on the same concept as the flapper excluder on the top but uses floatation to bring the panel up from the bottom of the net. Fish attempting to access the lower escapement hole need to swim forward and down against the flow. The lower "scooped" escapement portal (in red) provides considerable room for fish escaping out the bottom. Like the hood at the top of the excluder, the scoop on the bottom is also designed to help retain the shape of the net and should serve as a counter force to whatever upward lift the hood on top creates while the net is being towed. The scoop achieves this shape by weight placed on its leading edge. The shape of scoop feature of the excluder is perhaps more easily visualized in the lower panel of Figure 15 which is a cross sectional view.

Given that the O/U excluder is a very new concept that has only been evaluated in one limited field trial (described below), we have elected not to provide detailed construction information from his report. Interested public can contact John Gruver directly for this (jgruver@ucba.org). It should be recognized from the outset, however, that this is a brand new excluder design with very little testing done to date. Based on our previous experience with the dissemination of information on new excluder designs, we want to be clear that our current knowledge on the performance of the O/U excluder does not allow us to know with any certainty how the device will work in conditions other than those encountered during the EFP trials in the Fall of 2012 (i.e. low catch rate fall pollock fishing).

The main difference in terms of construction of the flume tank model compared to the excluder tested in the fall of 2012, besides the scale difference, is that the trawl floats seen in the flume tank model were replaced by float rope. This was done to help reduce drag while towing and to decrease the chance that the hood or bottom panel of the O/U would become snagged during deployment of the net. Likewise to further avoid potential for materials to become snagged during setting and retrieval, lead line was used on the excluder that was field trialed in lieu of the chain seen in the flume tank model.

<u>Testing plan for the fall 2012 Field trials of the Over and Under salmon excluder</u>
Two catcher vessels (F/V Destination and F/V Pacific Prince) were selected to participate in the testing via the same NMFS-led application review process used in all prior salmon excluder EFPs. Given that the first trials of a new excluder have often required long hours of adjustment before formal testing can commence, only catcher vessels were sought in the request for proposals (RFP). We adopted this approach based on our previous experience where it has proven difficult for catcher processors to do "beta testing" of new excluder designs in early stages of development due to more down time and the higher associated costs.

The original plan during the flume tank work in fall 2011 was to reserve some time for the development of a model recapture net that would be used to figure out how to fly a recapture net on the bottom of the net to capture escaping salmon and pollock from the lower escapement portal. A workable recapture net on the bottom is not a trivial matter. Due to the number of days it took to get the O/U excluder to a workable concept, however, we ran out of time before we could start work on a model for a recapture net on the bottom.

Additionally, as we considered the possibility of large amounts of pollock escapement with the O/U excluder, the practicality of using a recapture net for the initial testing of this device was an issue. This is because there was no way of knowing how great pollock escapement would be. As was discussed above, recapture nets are a statistically powerful way to determine the effectiveness of an excluder device. However they can be impractical if the escapement fraction is large enough to create handling problems on deck or in the extreme if escapement is large enough to deform the shape of the net where the recaptured fish are collected. From our experience, pollock escapement of over 5 mt per tow is the practical upper limit and escapement of around 10 mt is likely to tear the recapture net and result in loss of the fish in the recap nets as well as the necessity for major repairs.

For all of the above reasons, we had to rethink our testing plan for the O/U in the fall of 2012. The only workable approach would be to rely on video to get some idea of escapement rates for this brand new excluder device. To do this, we decided that two underwater cameras would need to be installed at each escapement portal so that the space could be adequately covered and data could be obtained reliably even if one camera in each location failed. The only camera video system that we knew to be small enough and sufficiently easy to install so that four cameras could be used on each EFP haul was a “tube camera” system under development by a video expert at the Alaska Fishery Science Center. This new system encases a small LED light, battery, camera, and recorder with 16 GB data storage card within a piece of four inch diameter clear acrylic (plexiglass) tubing. These systems are lightweight and the camera records the video through the clear tubing. . Each system is approximately twenty inches long and weighs only about six pounds on land, approximately 13 lbs when mounted on a small mounting board with stainless steel ‘quick clips” for rapidly attachment and detachment to the net. Given the need to have four cameras in the water at once during the EFP testing, a total of six of these systems were purchased so that cameras could be rotated to allow for charging between tows.

The specific location for each camera was a big question for the EFP testing. From our pre-trial tows, we learned that cameras facing each other tended to create a shine or halo effect that reduced the quality of the imagery for counting fish escapement or even distinguishing between salmon and pollock. Cross-sectional views also presented problems for producing images for the purposes of our EFP. In the end, a V shaped orientation with the two cameras mounted fairly close together on each flapper looking out each escapement pathway was adopted as the most viable approach. With this orientation, the cameras were arranged to look out the escapement pathway with some overlap but with full coverage of the space. This reduced effects of the light from one camera system on the other as well. With some overlap in viewing area, a time-synchronized review of images would help us to distinguish salmon from pollock or even possibly help with detection of the species of salmon with a different camera angle on a single fish proving a better opportunity.

In recognizing the limitations of video for tracking escapement rates, the objective for our first look at this new device was a rough assessment/quantification of salmon escapement based on what we could detect from the video compared to the number of salmon collected in the codend of the main net for each haul (by species). Even this might not be possible if relatively high rates of pollock escapement occurred which could keep the reviewers of the footage from being able to detect all the salmon as they passed by the cameras if this occurred during high levels of pollock escapement. Even if pollock escapement rates were relatively manageable, the pace of fish swimming past the cameras would also need to be slow enough to distinguish individual fish.

In electing to use cameras to track escapement, we also recognized that if pollock escapement was high, counting pollock escapes would be impractical. Under this scenario, we would have to fall back creating an index of the rate pollock loss for each tow or sections of the video from each tow. This would only allow us to give a relative measure of escapement (i.e., low, medium, high).

Finally, the question of how artificial light affects escapement would need to be largely ignored for these preliminary trials of the O/U excluder. In recognition of what we learned in our one season of trials adding artificial light, we did strive to position the cameras as close as possible to the escapement holes to avoid effects from the added light. Assuming salmon are attracted to the light, at least they would be close to the escapement point where they might sense the proximity of an escapement opportunity and exit the net despite their attraction to light. The only other step taken to reduce the effect of the light was to adjust the brightness of the camera light to its lowest level.

With six cameras available for the EFP and the need for four per vessel, testing on EFP vessels was done in succession rather than simultaneously. As a result, fieldwork on Pacific Prince occurred first with the pre-EFP tows starting on August 19th. This involved about 1.5 days of pre-trials to perfect the camera placements. Formal testing occurred from August 20 to September 10. Once the actual EFP testing was begun, camera positions and excluder configuration were kept as constant as possible so as to avoid introducing possible effects on performance that result from changes to the testing methods themselves.

<u>Escapement results of the first trials with the O/U excluder under relatively poor pollock catch rate conditions</u>

Overall, the pollock fishing conditions during the trials on Pacific Prince were not very representative of the Bering Sea pollock fishery. This was due to the fact that the EFP vessels were not available to start the EFP until after their B season regular pollock fishing. This meant the EFP commenced at a time of year that catch rates can be quite low. Specifically, the average groundfish catch rate for Pacific Prince in the EFP was 4.5 metric tons of groundfish per hour across all EFP tows with per-tow catch rate ranging from as low as 1.9 mt per hour to as high as 15 mt per hour. The number of towing hours during the EFP tests on Pacific Prince was 190 hours during which approximately 1,200 mt of groundfish were caught.

Following the conclusion of testing on the Pacific Prince, the EFP personnel moved to F/V Destination where EFP testing occurred between September 12-20th and camera placements were in the same locations as those used on Pacific Prince. Pollock fishing catch rates were even lower for Destination’s test with 94 hours of towing during the EFP for320 mt of groundfish. Average catch rate was approximately 3 mt per hour with the highest hourly rate per tow at 4.5 mt and the lowest about 1.5 mt per hour. In reality, the pollock catch rates were so low during the testing on the Destination that premature curtailment of the testing with only a fraction of the expected testing completed became the only viable option. This is because the primary objective was to evaluate the excluder’s performance in conditions with relatively high salmon bycatch rates and representative pollock fishing conditions. With the latter not really being the case, we decided to stop the EFP once we were able to determine that the O/U excluder was taking the desired shape and appearing to perform as it had on Pacific Prince.

Over the course of month of testing on the two vessels, four cameras were successfully deployed in the desired locations on nearly all tows. The cameras systems were designed to have sufficient electrical charge and data storage to last approximately 8-10 hours per deployment. On a few occasions, however, only one camera functioned correctly and on several tows just one of the cameras had sufficient battery life to cover the entire tow when tow times exceeded 8 hours. Uneven charging of the battery packs by the charger systems or problems with the batteries themselves was likely the cause of this latter problem. Three of the tows over the month of testing had durations of considerably greater than 10 hours due to weather conditions and other gear problems that did not allow the gear to be retrieved at the scheduled time. For these, data were collected for the portion of the tows when the cameras were functioning only and we did not attempt to extrapolate escapement rates/amounts for the proportion of the time when video data were not collected.

Prior to the start of the EFP testing, a series of pre-trial tows were made on each vessel to evaluate whether the excluders were achieving the desired shape at normal towing speeds. The pre-trial tows were also intended to verify that the planned camera locations adequately covered the pathways out of the net so that escapement could be tracked when the footage from both the lower and upper escapement portals was reviewed following the EFP. Figure 18 shows the top escapement pathway and escape portal above the weighted panel. Escapement was tracked with the two cameras in this location (one aimed to the port side, the other one to starboard). The desired shape of the escapement tunnel was achieved in this section of the excluder, as seen in the figure.

Figure 19 shows the bottom escapement portal including the scoop and the floated panel that creates the pathway on the bottom of the net. Some adjustments in the floatation on the webbing panel were needed during the pre-trial tows to get this panel to take the proper shape. Once these modifications were made, however, the bottom escapement panel achieved the desired shape without fail throughout the testing.

Finally, Figure 20 shows a cross section of the excluder panels taken with a sonar imaging device installed in the excluder section. This sonar cross-section shot confirmed that the upper and lower parts of the O/U excluder were taking the desired shape and the proportion between the upper and lower sections of the excluder was as designed. The sonar unit was installed on the side so the image shows top and bottom as left and right.

Figure 18. upper escapement panel and upper escapement portal (port camera)

Figure 19. Lower escapement panel and scoop. Note float rope at the top of the figure.

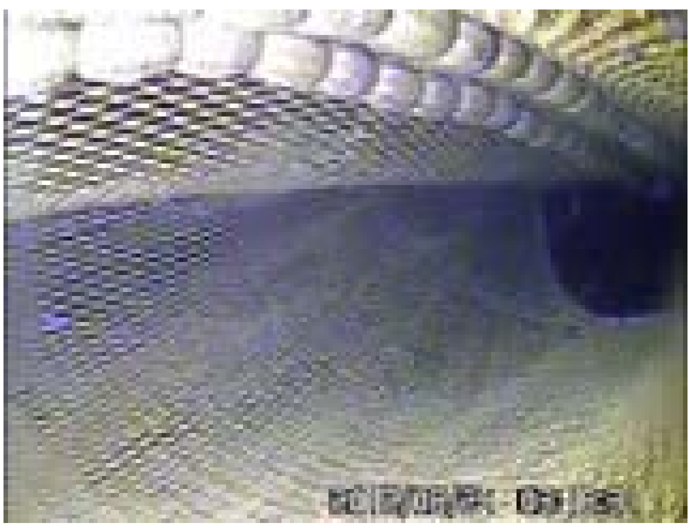
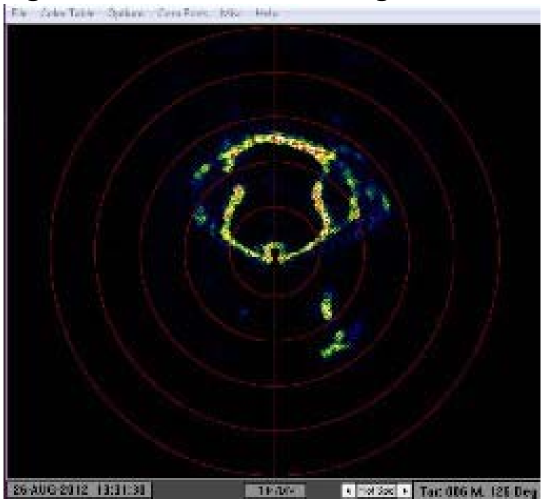


Figure 20. Cross-section image of Over and Under excluder from recording sonar



Results from preliminary review of EFP video O/U testing on Pacific Prince

Following the EFP testing, the video from the EFP was reviewed by the project manager who supervised the fieldwork on both EFP vessels and another former salmon excluder project manager with extensive experience with video deployments on previous salmon excluder EFPs. Each reviewer reviewed portions of the 1,132 hours of video collected during the field trials on Pacific Prince alone with portions of the same video footage reviewed by the two reviewers to ensure that methods were consistent.

Note that we have arranged to have another detailed review of all of the video files under the direction of Dr. Brad Harris of Alaska Pacific University which is expected to be completed during the first half of 2013. The objective of the second review is to allow for an independent assessment of our methods and our assessment of the escapement results.

The initial video review by our project managers utilized a time synchronization of the footage approach for the two side-by side cameras that were monitoring the same escapement portal. Once synchronized, the reviewer played the two views at a relatively fast pace until there was evidence of activity (fish passing in front of the cameras monitoring the escapement portals). At those points in the footage, the video playback pace was slowed to allow the reviewer to count escaping fish, whether salmon or pollock. To evaluate pollock escapement rates reviewers noted the relative rate of pollock escapement (low, medium, high) or estimated the number of Pollock escaping, applying an average weight to the number to generate an escapement rate. Time-specific notes were kept of the tallies of salmon escapes as well as rates of pollock escapement.

After doing a pre-review of random sections of the footage, our reviewers determined that pollock escapement overall appeared to be low and that it was unlikely that our concerns over pollock obscuring salmon escapement would be realized. That pollock escapement was minimal was in fact consistent with the comments of the captain of the Pacific Prince during the EFP testing who thought that the catch rate of pollock was not affected negatively by the use of the O/U excluder. He based his determination on the amount of pollock sign entering the net as seen through the vessel's net sounder (third wire) output and the time needed to fill the codend.

After starting their review, the reviewers soon reported that they would be unable to definitively distinguish between chum and Chinook salmon for the majority of the salmon escapes. This determination was made based on the quality of the video images and the time that most salmon spent close enough to the camera where images might be suitable to make a determination as to salmon species. While not completely unexpected, this was a disappointing result because we were specifically interested in knowing if the device worked better than other approaches with chum salmon and based on our experience with earlier tests, we had to presume that Chinook escapement would possibly be higher than chum. Not being able to definitively distinguish what species was escaping complicated our assessment of the O/U device for its main intended purpose. This issue will be discussed further below.

Lacking the ability to determine species of salmon definitively from the video, based on the timing of the EFP, our expectation was that the vast majority of the salmon encountered would be chums. This was particularly true for Pacific Prince where most of the EFP occurred in August. Based on recent experience in the Bering Sea pollock fishery, Chinook bycatch can in some years start to increase in September but chums are still the predominant bycatch salmon species in the pollock fishery in September.

Based on salmon collected in the Pacific Prince's codend, chums were the predominant species with only 20 Chinook caught out of a total of 537 salmon recovered in the codend of Pacific Prince (97% chum). Likewise, there were 47 Chinook of 296 salmon recovered in the codend of Destination or 85% chum salmon. Because we have observed that Chinook can escape at different rates than chums in trials with past excluders, however, we are not able to assume that the codend salmon catch exactly reflects the proportion of chum to Chinook for escaping salmon. Nonetheless, we are comfortable with the assumption that most of the salmon escapement in our test of the O/U was comprised of chums based on the fact that the testing on Pacific Prince occurred at a time when chums would be expected to be the prevalent species of salmon in the catch.

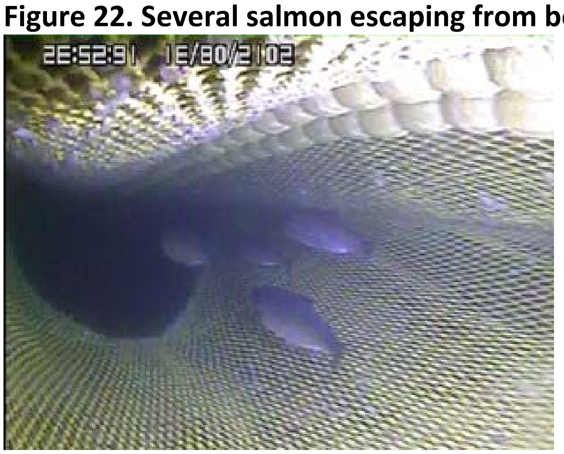
Based on the preliminary video review, we estimate that the salmon escapement rate for Pacific Prince was approximately 20% by number (130 of a total of 667). The 95% confidence interval around this result is quite large due to the relatively high variability in escapement rates between tows (Figure 6). It is also important to recognize that this estimated escapement rate is the number of salmon confirmed to have escaped from the video relative to the total catch of salmon (number of escaped salmon divided by number of chums and Chinook recovered in codend plus escaped salmon from the video). Considering that we applied a conservative approach to our review methods (not to count a fish as escaped unless it could be definitively seen to swim out of the net), this may be a lower bound estimate of salmon escapement. In this regard, it was not uncommon to have salmon milling around at the escapement portal and some of these could not be confirmed to escape even if they were not seen to return to the field of view because of lapse in the footage or the limitations on visibility under different conditions.

To help the reader visualize a salmon escapement, Figure 21 shows a salmon escaping via the bottom escapement portal. Due to the good water clarity for this particular tow, reviewers noted that the fish escaped and also that it was likely to be a Chinook. This image from the video was taken by the camera on the starboard side of the bottom escapement pathway.

Figure 22 shows several salmon prior to their eventual exit from the lower escapement portal.

Figure 21. Salmon escaping from the lower portal of the excluder

Figure 22. Several salmon escaping from bottom excluder seen from port side camera



Based on review of the escapement sequences on Pacific Prince, escapement from the upper portion of the excluder appeared to be relatively effortless in many of the video frames. Figure 23 illustrates a typical view of a salmon moving forward and out of the net above the flapper panel with relative ease and in a matter of a few seconds.

Figure 23. Escapement out the top portion of the excluder during Pacific Prince EFP

One of the most surprising results from the video review from Pacific Prince testing was the fraction of escapement from the top escapement portal compared to the lower portal. Because we had never had much success with chum escapement with an excluder rigged to allow escapement out the top, our expectation was that if chum escapement rates were relatively high compared to results with past excluders, then it would be due to escapement out the bottom escapement hole. For Pacific Prince, roughly 80% of the escapes were out the top of the net, however, raising the issue of how having the two panels changing the water flow in the net, one above the other, might affect water flow and escapement behavior. Another possibility is that the hood on the top and the scoop on the bottom could be changing water flow as well.

Finally, it is difficult to compare results from tests with recapture nets to test with video for many reasons and it is possible that top escapement is more likely just due to the lack of a recapture net.

Another unexpected but rather welcome result was the negligible pollock escapement. As was mentioned above, some attendees at the flume tank sessions thought that pollock escapement rates might be unacceptable given the additional opportunity for escapement out the bottom. While our reviewers for this initial review did not actually count pollock, both have extensive experience examining video from salmon excluder trials in the past where recapture nets were used. This allowed them to estimate the amount of Pollock escapement. Both reviewers estimated Pollock escapement at less than 1%.

In considering this result, however, one should keep in mind that pollock catch rates were relatively low for the fishery at the time that our testing occurred (late August to early September 2012).

Results for trials on F/V Destination:

As was mentioned above, pollock fishing conditions were dropping off as a result of the normal dispersing of pollock that tends to occur in the Bering Sea in most years in the fall. With groundfish catch rates as low as they were on Destination, we decided to use the opportunity to observe whether the device seemed to take the same shape when installed in Destination's net and unless pollock catch rates improved over the time we had our EFP crew on the vessel, do just enough fishing to do a gross assessment of whether fish appeared to react to the excluder in the same way as what we observed on Pacific Prince.

With this scaled-down plan for work on the Destination, a series of pre-trial tows were done by which we were able to determine that the O/U's shape was quite similar to what was seen on Pacific Prince. One difference was that the mesh openings and relative rigidity of the netting in the excluder was lower on Destination compared to Pacific Prince. Another difference was that the net appeared to move up and down in rapid short pulses on the Destination which was something that was not seen on the P. Prince. This latter could be caused by a number of factors including warp setting ratios and sea state during testing but this factor is not expected to have affected the performance of the excluder. The issue of tension on the netting could be a factor if the difference was great given that tension and mesh opening ratios are indicators of water flow which we know has an effect on escapement rates at some level.

Again because our testing conditions were not very representative of normal pollock fishing conditions, especially on the Destination, we have to be cautious about the applicability and representativeness of our observations on escapement rates. Review of the video from Destination showed escapement rates to be very similar to what was seen on Pacific Prince. For pollock, escapement rates were, according to the reviewers "very, very low", actually in the hundreds of fish over the course of catching roughly 320 mt of groundfish (at very low catch per hour rates). Keeping in mind the caveat about the low pollock catch rates during this testing and the small overall amount of testing hours on Destination, it is still notable how low pollock escapement rates were for this test.

Overall, salmon escapement rates were quite similar to those of P. Prince. The overall salmon escapement rate was 24% with 94 salmon escapes out of a total of 390 salmon. The breakout of salmon recoveries in the Destination's codend was 47 Chinook and 296 chums, indicating a larger fraction of Chinook in the catch relative to chums as would be expected for testing that stretched into the second half of September. The confidence intervals around the 24% escapement rates are in fact considerably tighter than those from the test on Pacific Prince (Figure 6) due to the lower variability in tow to tow escapement rates for Destination.

The significance of lower variability needs to be understood in the context of the lower groundfish catch rates for the Destination since groundfish catch rates are likely to be one of the most important determinants of salmon escapement. Salmon have to navigate their way to the escape portal against the pollock moving towards the codend. With low catch of groundfish, this task might have been easier for the salmon and therefore the conditions for this testing may not reflect performance with higher catch rates of groundfish.

Just as occurred with Pacific Prince, escapement from the bottom portal of the excluder comprised only a small fraction of overall escapement (in this case only about 8% of the confirmed escapes). As regards results from Pacific Prince, an explanation for this counter-intuitive result is not available but one has to keep in mind that this O/U excluder may change water flow conditions so profoundly that past observations of salmon behavior in response to an excluder may not be relevant.

Overall (preliminary) findings for the O/U excluder test

Recognizing the limited testing done on the first O/U excluder, the testing conditions not being very representative of typical Bering Sea pollock fishing, and the fact that our review of the video footage is preliminary until Alaska Pacific University's review is completed, some conclusions can still be made at this point.

First is that the O/U excluder achieved the intended shape on two different vessels during our limited test. This is important because the location of the O/U is in the tapered section of the intermediate where water flow is higher. This holds the prospect of consistency in excluder shaping which could be important for eventually having an excluder that can be installed in a wider set of classes of pollock vessels (low vs. high horsepower) with less need for fine tuning of weight and floatation between vessels within classes than the current flapper excluder. This is because water flow differences between vessels are likely to be lower in the tapered section than in the straight section where the 2010 flapper excluder was located.

Second, with the O/U installed, salmon escapement occurred at a meaningful rate with very low pollock escapement. The low pollock catch rate during testing needs to be considered. The low pollock catch rate conditions may possibly have led to higher escapement rates for salmon with little pollock to block or obscure the escapement opportunity. Further testing will be needed under more representative conditions to answer these remaining questions about the pollock and salmon escapement rates and hopefully some of this can be done with a recapture net so that at least species identification for salmon escapement can be more definitive.

While nothing definitive can be said about the prospects for the O/U excluder from our tests, there is good reason to believe that this excluder could reduce pollock loss rates to even lower than the flapper excluder due to its location in the tapered section of the intermediate where water flow is greater. At the same time, given that it showed some relatively high escapement rates for chums it may provide the first effective excluder to help fishermen reduce their chum bycatch rates. Finally, there is potential for this excluder to be at least as effective for Chinooks as the current flapper excluder. A dedicated test during the winter months would be needed to evaluate this potential but from the design aspects and what we know about the swimming ability of Chinook, there is considerable reason to expect that Chinook escapement will be improved with the O/U as well.

EFP Groundfish and Salmon Accounting

Error! Reference source not found. and **Error! Reference source not found.** detail groundfish and salmon accounting for the EFP trials by season, vessel and species. Of the 7,500 mt groundfish limit for this EFP, 5,868 mt were harvested (78.2%). Of this, 96.9% was pollock. Halibut bycatch was 8.86 mt or .15% of the total catch. For catcher vessels, ADF&G fish tickets were used for groundfish species. For the *Starbound* (CP), estimates for groundfish were derived from at-sea partial haul sampling. Weight of salmon sharks discarded from deck is included. The sea sampler counts (by haul, at-sea) were used for all salmon accounting.

Table 7. EFP 11-01 limits and harvests: 2011B, 2012 A/B. *Starbound* , *Destination*, *Pacific Prince*

	Limits	2011 B/SB	2012 A/SB	2012 A/Dest	2012 B/Dest	2012 B/PP	Totals	Remaining	% used
Groundfish	**7,500**	1,945	1,247	1,219	313	1,145	5,868	1,632	78.2%
Chinook	**850**	59	236	223	47	20	585	265	68.8%
non-Chinook	**5,125**	2,165	0	0	249	517	2,931	2,194	57.2%

Table 8. EFP 11-01 salmon and groundfish accounting by species, season and vessel (SB= *Starbound*, Dest = *Destination*, PP=*Pacific Prince*). Catcher vessels: Fish Ticket amounts for groundfish (mt), sea sampler counts for salmon; *Starbound* (CP): estimates for groundfish from partial haul sampling, sea sampler counts for salmon.

Species (mt)	2011 B/SB	2012 A/SB	2012 A/Dest	2012 B/Dest	2012 B/PP	Totals	% of total
King Salmon (no.)	59	236	223	47	20	**585**	na
Chum Salmon (no.)	2,165	0	0	249	517	**2,931**	na
Pollock	1,913	1,218	1,199	307	1,068	**5,705**	96.9%
Halibut	0.332	4.431	0.297	0.320	3.480	**8.860**	0.15%
Herring	0.002	0.000	0.000	0.000	3.370	**3.372**	0.06%
Cod	12.291	8.271	10.783	1.950	5.250	**38.545**	0.65%
Arrowtooth	4.380	1.972	0.600	1.230	3.010	**11.192**	0.19%
Kamchatka	0.383	0.141	0.000	0.000	0.000	**0.524**	0.01%
Flathead	10.209	5.167	5.529	0.670	2.880	**24.455**	0.42%
Bering Flounder	0.000	0.007	0.000	0.000	0.000	**0.007**	0.00%
Rock sole	0.565	5.813	0.943	0.040	0.230	**7.591**	0.13%
Yellowfin sole	0.000	0.369	0.001	0.000	0.000	**0.370**	0.01%
Rex Sole	1.098	2.750	0.790	1.100	4.600	**10.338**	0.18%
AK Plaice	0.000	0.006	0.001	0.000	0.000	**0.007**	0.00%
Turbot	0.002	0.003	0.000	0.000	0.000	**0.005**	0.00%
POP	0.001	0.154	0.005	0.040	11.560	**11.759**	0.20%
Northern rockfish	0.002	0.000	0.000	0.000	0.000	**0.002**	0.00%
Redstripe RF	0.000	0.006	0.000	0.000	0.000	**0.006**	0.00%
Dusky rockfish	0.000	0.000	0.001	0.000	0.000	**0.001**	0.00%
Shortraker	0.000	0.011	0.000	0.000	0.000	**0.011**	0.00%
Atka mackerel	0.000	0.000	0.013	0.000	0.850	**0.863**	0.01%
Octopus	0.000	0.000	0.000	0.000	0.000	**0.000**	0.00%
Squid	0.000	0.178	0.001	0.290	47.060	**47.529**	0.81%
Shark	0.970	0.129	0.000	0.400	0.110	**1.609**	0.03%
Sculpin	0.691	0.476	0.043	0.010	0.050	**1.270**	0.02%
AK Skate	1.048	2.751	0.000	0.000	0.000	**3.799**	0.06%
Bering Skate	0.051	0.037	0.000	0.000	0.000	**0.088**	0.00%
Aleut Sk	0.072	0.157	0.000	0.000	0.000	**0.228**	0.00%
Skate unid	0.000	0.000	1.451	0.050	0.510	**2.011**	0.03%
Sablefish	0.000	0.000	0.000	0.000	0.030	**0.030**	0.00%
Jellyfish	8.407	0.256	0.099	0.060	0.880	**9.701**	0.16%
Prowfish	0.015	0.000	0.000	0.000	0.000	**0.015**	0.00%
Starfish	0.001	0.002	0.000	0.000	0.000	**0.003**	0.00%
Poacher	0.004	0.003	0.001	0.000	0.000	**0.008**	0.00%
Misc	0.002	0.000	0.000	0.000	0.000	**0.003**	0.00%

Species (mt)	2011 B/SB	2012 A/SB	2012 A/Dest	2012 B/Dest	2012 B/PP	Totals	% of total
Eulachon	0.002	0.000	0.000	0.000	0.000	**0.002**	0.00%
Lumpsucker	0.165	0.159	0.023	0.010	0.000	**0.357**	0.01%
Snailfish	0.000	0.022	0.000	0.000	0.020	**0.042**	0.00%
Sponge	0.000	0.001	0.000	0.000	0.000	**0.001**	0.00%
Tanner crab	0.000	0.003	0.000	0.000	0.000	**0.003**	0.00%
Totals (mt)	**1,953.7**	**1,251.3**	**1,219.6**	**313.2**	**1,152.4**	**5,890.1**	**100.0%**
Total groundfish (mt)	**1,944.8**	**1,246.4**	**1,219.2**	**312.8**	**1,144.6**	**5,867.7**	
groundfish excludes prohibited and non-allocated species							

Acknowledgements: The authors wish to express their appreciation to the captains and crews of the vessels used in EFP 11-01 (captains were Karl Bratvold on the Starbound, Jack Jones on the Pacific Prince, and James Buskirk on the Destination). We thank each of them for their patience and dedication to following our testing protocol and their suggestions for improvements to excluder designs and testing methods.

We also want to thank the board members of the North Pacific Fisheries Research Foundation who have encouraged and supported our work on salmon excluders through both the high and low points over the past ten years.

We thank Carwyn Hammond of the AFSC for pre-testing video and sonar work at several stages of this project. This helped us begin EFP testing with devices that were close to the intended shape. We also want to acknowledge the work by Mary Grady and Melanie Brown at NOAA's Alaska Region of NMFS who endeavored long hours to write Environmental Assessments and other necessary documents, without which this salmon excluder EFP would not have been possible.

The authors also extend a big "thank you" to Robert Dooley, owner of the Pacific Prince, for his long term commitment to the successful development of a salmon excluder and willingness to continue EFP testing even at times when his vessel was unable catch enough pollock to cover fuel costs. We also thank the owners of Pacific Prince and Starbound for making their vessels/crews available during the regular pollock season to do pre-EFP video work on excluder designs.

We also want to recognize the work of Seamus Melly and his crew at Swan Nets USA who constructed our excluders, frequently under challenging timelines. The authors would also like to acknowledge the assistance and expertise of Harold DeLouche and Tara Perry at Memorial University's Marine Institute during the design stage of our new excluder in the flume tank facility in St. Johns, Newfoundland.

Finally, we thank all the pollock captains, crew, and gear manufacturers who have helped us in many small and large ways over the course of this EFP including their willingness to take the time to go to the flume tank to work long days on excluder models and testing.